AY23 Project Proposal

Instructions: Fill up the boxes. Submit this word document into NTULearn > Teams by the stated deadline. If there are major changes to proposal after submission, inform your instructor via email and re-submit. If there are too many teams that prefer a particular week, balloting will be done to fairly assign the project presentation timeslots and announced in NTULearn.

Class/Sem:	AY23 Sem 2 RE6013	Team:	10
Preferred Project Presentation week:			Week 12

Project Title
[Tentative and can be changed later.] Predictive Maintenance of Essential Machinery: A Data-Driven Approach for Oil and Gas Industry Resilience

Business Problem or Opportunity Statement
[Define precisely and concisely the business problem or opportunity statement.] A key business problem for Aramco is to optimize the maintenance and performance of its critical assets, such as refinery equipment and machinery. The opportunity lies in implementing predictive maintenance using advanced analytics and machine learning techniques. We show this by leveraging datasets like the NASA Turbofan Jet Engine Data Set. The implementation of predictive maintenance is imperative for Aramco due to the substantial financial and operational ramifications associated with unplanned downtime in the oil and gas industry. The traditional reactive or scheduled maintenance practices may lead to inefficient resource allocation and potentially compromise safety. The adoption of predictive maintenance, addresses these challenges. This approach enables Aramco to anticipate and mitigate equipment failures before they occur, optimizing maintenance schedules, extending the lifespan of critical assets, and ensuring operational continuity. By proactively managing asset health, Aramco not only reduces downtime costs but also enhances safety, operational efficiency, and overall competitiveness in the industry.

Reasons

[Why did your team choose this Problem/Opportunity Statement? Any special reasons?]

1. **Industry-Specific Challenges:** The oil and gas industry, where Aramco operates, is highly dependent on the reliability and efficiency of its equipment and machinery. Unplanned downtimes due to equipment failures can have severe financial and operational consequences. Therefore, it is imperative that Aramco can accurately forecast when its equipment requires maintenance to prevent such unplanned downtimes.
2. **Predictive Maintenance:** Implementing predictive maintenance is crucial to help Aramco reduce unplanned downtimes as it enables Aramco to identify potential equipment failures before they occur. By leveraging predictive maintenance, Aramco can use patterns and trends in the time series collected from their equipment and predict the likelihood of failure in critical machinery.
3. **Operational and Financial Efficiency:** Predictive maintenance can lead to substantial cost savings by reducing unplanned downtime, extending the lifespan of critical assets, and optimizing maintenance schedules. This improves Aramco's efficiency and results in better financial performance.
4. **Enhancing Safety and Environmental Compliance:** Predictive maintenance also empowers Aramco to have more predictable schedules, thereby improving safety outcomes and reducing the risk of incidents that may have environmental impacts. This proactive aligns with global standards and regulations, reinforcing Aramco's commitment to safety and environmental stewardship.
5. **Use of Advanced Technologies as POC:** The use of the NASA Turbofan Jet Engine dataset to generate a proof of concept model showcases the practical application in a very similar industry. This demonstrates the potential for Aramco to apply the same strategies and technologies in its maintenance strategies.

Data Sources

[Where will you get the data? Provide links to data source.]
We will be using the NASA Turbofan Jet Engine Data Set downloaded from Kaggle: https://www.kaggle.com/datasets/behrad3d/nasa-cmaps

This is a well-known public dataset for asset degradation modeling from NASA containing Run-to-Failure simulated data from hundreds of turbofan jet engines. It consists of multiple multivariate time series of the operational life of turbofan jet engines, each with more than 20 features containing sensor data and engine operational settings. Users can perform prognostics on this dataset by estimating the remaining useful component life (RUL) of engines based on the time series of their sensor data and settings. End-of-life can also be determined as a function of the operational thresholds that can be subjectively determined by user specifications based on safe operational limits.

As first described in A. Saxena, K. Goebel, D. Simon, and N. Eklund, Damage Propagation Modeling for Aircraft Engine Run-to-Failure Simulation, in the Proceedings of the 1st International Conference

on Prognostics and Health Management (PHM08), Denver CO, Oct 2008, in the dataset was used as challenge data for the Prognostics and Health Management (PHM) data competition at PMH'08.

The system model C-MAPSS (Commercial Modular Aero-Propulsion System Simulation) was used to simulate complex commercial turbofan engines while allowing input variations of health related parameters under a multitude of operating environments such as varying altitudes, mach numbers, and sea-level temperatures.

Important References

[What are the important publications or prior analysis done? Provide the links or docs.]

Predictive maintenance has been used extensively in the aerospace industry, with systems monitored by multiple sensors that generate large volumes of data. Several AI algorithms have been developed in the past years to estimate the Remaining Useful Life (RUL) of components and systems [1]. The integration of data-driven RUL prognostics into maintenance planning has been shown to significantly reduce maintenance costs and the number of failures [2], by determining the optimal maintenance schedules for replacing and repairing components to maximize their lifespans [3]. The proliferation and integration of such advanced technologies have led to Industry 4.0, utilizing data analytics and machine learning methods to change production procedures [4].

Just like the aerospace industry, the oil industry is able to utilize predictive maintenance through employing sensor technology throughout their critical equipment to monitor equipment health, detect anomalies and predict potential failures, such as for pumps, compressors, turbines and pipelines. Thus, we seek to investigate the features and challenges of predictive maintenance for turbofans and apply our findings to help Aramco management modernize their maintenance processes in a similar way.

Links:
[1] https://www.sciencedirect.com/science/article/pii/S095183202300114X#sec6
[2] https://www.sciencedirect.com/science/article/abs/pii/S0951832016303714
[3] https://incose.onlinelibrary.wiley.com/doi/full/10.1002/sys.21651
[4] https://www.sciencedirect.com/science/article/abs/pii/S0360835220305787

Project Schedule and Milestones

Week 7 (Project Initialization and Data Exploration)

- Initial review of the NASA CMAPS dataset to understand its structure, features, and potential challenges.
- Document initial findings and hypotheses for predictive maintenance models.

Week 8 (Data Preprocessing and Feature Engineering)

- Complete data cleaning (handling missing values, outlier detection).
- Begin feature engineering (creating new variables that could enhance model predictions).
- Prepare a detailed report on the data preprocessing steps and the rationale behind chosen features.

Week 9 (Model Development and Training)

- Select and implement appropriate machine learning algorithms.
- Train models on the preprocessed dataset.
- Conduct initial model evaluation using validation sets and refine models as needed.

Week 10 (Model Evaluation and Refinement)

- Perform comprehensive model evaluation using various metrics (accuracy, precision, recall, F1 score).
- Refine models based on evaluation results; fine-tune parameters.
- Prepare a final model that optimally predicts equipment failures.

Week 11 (Finalization and Presentation)

- Finalize the written report, ensuring it clearly articulates the problem statement, methodology, model evaluation, and business implications.
- Create a PowerPoint presentation to show our key findings, insights, and recommendations for Saudi Aramco. (Focusing on the business impact and implementation strategy)
- Submit the report and slides.
- Prepare for project presentation

Key Responsibilities
[State the Key Responsibilities of each team member.] Jared: Project management and coordination (Ensure all components align with project goals) Riley: Industry research and analysis (Analyze the benefits of predictive maintenance) Dhruval: Data exploration and Model conceptualisation (Review dataset and conceptualise model) En Ning: Literature Review and Documentation (Identify key publications and document findings) Samuel: Preprocessing and Analysis (Data cleaning and Feature engineering)